Health & Place 46 (2017) 257–266

Contents lists available at ScienceDirect

Health & Place

journal homepage: www.elsevier.com/locate/healthplace

How do moving and other major life events impact mental health? A longitudinal analysis of UK children

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A B S T R A C T

Research has suggested that children who move home report poorer mental health than those who remain residentially stable. However, many previous studies have been based on cross sectional data and have failed to consider major life events as confounders. This study uses longitudinal data from ALSPAC, a UK population based birth cohort study, and employs within-between random effect models to decompose the association between moving in childhood and poor mental health. Results suggest that while unobserved between-individual differences between mobile and non-mobile children account for a large portion of this association, within-individual differences remain and indicate that moving may have a detrimental impact upon subsequent mental health. There is heterogeneity in children's response to moving, suggesting that a dichotomy of movers vs stayers is overly simplistic.

1. Introduction

Mental ill health is one of the largest contributors to the global burden of disease and a major global health priority, inflicting a number of health, social and personal burdens upon individuals (Whiteford et al., 2013). Between 10% and 20% of children and adolescents worldwide suffer from mental health problems (Kieling et al., 2011), a rise from 10% at the turn of the millennium (Meltzer et al., 2000). In the UK recent estimates put this figure between 12.5% (Beardsmore, 2015) and 20% (Fink et al., 2016), depending on the definition of poor mental health. Childhood and adolescence are critical developmental periods for identification and intervention of mental ill health because problems in early life are associated with both higher likelihood (Helliwell et al., 2015) and longer durations (Kovacs et al., 1984) of mental ill health in adulthood. Mental illness costs the UK between £70 and £100 billion a year, of which between £14 and £20 billion is spent on health and social care costs (Mental Health Foundation, 2015). The socioeconomic patterning of mental health has been studied in detail, with children growing up in households characterised by low family socioeconomic position (SEP) suffering from an elevated risk of problems compared to those in high SEP families (Reiss, 2013). However, beyond these broad patterns there is still a lack of understanding on the specific social pathways that may contribute to child mental illness.

1.1. Moving house and mental health

One potential social pathway is the role of place, and in particular how transitions between places may be linked to mental health. Evidence suggests that individuals who are exposed to moving house (commonly termed residential mobility), report poorer mental health than those who do not (Jelleyman and Spencer, 2008; Morris et al., 2016b). This is particularly true for children and adolescents; findings from the UK suggest that young families with children who move have poorer mental health than those who remain residentially stable (Tunstall et al., 2012, 2010), and that children and adolescents are particularly vulnerable to deleterious mental health effects of moving (Anderson et al., 2014; Flouri et al., 2013). Such effects are thought to operate through a number of pathways including weakened social ties (Pribesh and Downey, 1999), disturbance to social networks (Coleman, 1988), 'social stress' (Silver et al., 2002), household disruption (Haveman et al., 1991), social isolation (Stubblefield, 1955), and

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http://dx.doi.org/10.1016/j.healthplace.2017.06.004
Received 19 January 2017; Received in revised form 6 June 2017; Accepted 22 June 2017

reductions in parent-child interactions (Anderson et al., 2014). Similar findings have been observed in the USA showing a dose response relationship (Susukida et al., 2015) and both short and long term negative associations between moving in childhood and subsequent mental health (Bures, 2003; Gilman et al., 2003; Oishi and Schimmack, 2010; Simpson and Fowler, 1994). However, it is important to note that there have been conflicting findings with a number of studies failing to replicate associations between moving and poor mental health (Gambaro and Joshi, 2016; Jelleyman and Spencer, 2008; Stoneman et al., 1999; Verropoulou et al., 2002). The conflicting results from these studies cannot be explained by a common research design or analytical method, though there is a suggestion that a detailed account of family circumstances may lessen the apparent association between moving and poor mental health. We return to this shortly.

1.2. Neighbourhoods and selective migration

Specific characteristics of places play an important role in the patterning of mental health in addition to individual and family level factors. Studies have long shown that mental health is poorer in socially, economically and environmentally deprived neighbourhoods compared to less deprived neighbourhoods (Kim, 2008; Leventhal and Brooks-Gunn, 2000; Mair et al., 2008). With respect to people moving through different types of neighbourhoods, studies have found that making moves to more deprived neighbourhoods is negatively associated with mental health over and above the effect of moving (Tunstall et al., 2014, 2012). This implies that varying exposure to such conditions is an important factor in the development of mental ill health under the assumption of instantaneous effects. The semi-randomised Moving To Opportunity (MTO) experiment in the USA has provided evidence that children who move from extreme high to low poverty neighbourhoods experience a reduction in mental health problems in adolescence and early adulthood (Bridge et al., 2012; Leventhal and Brooks-Gunn, 2003; Ludwig et al., 2012). The MTO studies have been substantially critiqued however (Clark, 2008; Manley and van Ham, 2012). There has long been debate as to whether the association between neighbourhood deprivation and poor health is due to a causal neighbourhood effect or a selection effect (Kawachi and Subramanian, 2007; Oakes, 2004) and very few studies have utilised data and methods suitable for answering such questions. However, recent studies using longitudinal data have suggested that the relationship between neighbourhood deprivation and poor health may be due to selective migration of unhealthy individuals into deprived areas, rather than a causal effect from neighbourhood deprivation to poor health (Jokela, 2015, 2014).

1.3. The impact of life events on mental health

One aspect that has been commonly overlooked in studies of mental health and migration is that of major life events (Morris et al., 2016b). It has long been accepted that adverse life experiences play a role in the onset of psychological conditions (Rutter, 1981), with a body of research suggesting that adverse life events and childhood adversity are strongly associated with poor subsequent mental health (Dong et al., 2005; Felitti et al., 1998). This finding is consistent across a range of events including union dissolution (Strohschein et al., 2005), parental death (Trotta et al., 2015), childhood abuse (Varese et al., 2012), unemployment and job loss (Paul and Moser, 2009), and 'total' adversity (Trotta et al., 2015). Experience of each of these events has been associated with poorer mental health and the experience of such social adversity in adolescence has also been linked to poor mental health development trajectories into adulthood (Rajaleid et al., 2016). In a detailed analysis of mental health survey data from 21 countries, Kessler et al. (2010) found that all childhood adversities examined were associated with psychiatric disorders, and that this association increased with multiple adversities.

1.4. Limitations of the literature

Many studies of moving and mental health do not examine the impact of life events, raising questions over the validity of findings. Moving is not an exogenous process: rather, it is a highly complex set of processes that are influenced by a wide range of factors, including major life events (Morris, 2017), which also directly influence mental health. However, few studies examining the impact of moving on mental health have considered the occurrence of major life events. Because of the robust relationship between life events and both moving and mental health, excluding such events is likely to introduce bias due to unobserved confounding and raises the possibility of spurious associations between moving and mental health (Morris et al., 2016b). Those studies that have accounted for life events find that their occurrence has a strong attenuating effect on associations between moving and poor mental health, either eliminating this association (Dong et al., 2005; Gambaro and Joshi, 2016) or heavily attenuating it (Flouri et al., 2013; Tunstall et al., 2015). These findings suggest that while moving house may be a constituent part of a child's story, it is likely the events that lead to moves rather than the moves themselves which are the main reason for differences between movers and stayers (Gambaro and Joshi, 2016).

1.5. Study aim

In this study we test the longitudinal association between moving in childhood and subsequent mental health, and determine whether this association is robust in the presence of major life events as confounders or if these induce spurious associations. Further, we decompose the association between moving and mental health to determine the extent to which any changes in mental health are due to the effects of moving or due to factors that are more common in mobile than non-mobile children. The use of longitudinal data allows us to model directional associations and provides greater freedom to draw causal inferences than the cross-sectional approaches that remain widespread throughout the literature. Given the ongoing health selection debate over whether moving causes poor mental health or poor mental health causes people to move, such a longitudinal approach allows us to correctly structure and test for temporal effects of moving to mental health.

2. Data and methods

2.1. Data source

We use data from the Avon Longitudinal Study of Parents and Children (ALSPAC). All pregnant women resident in the (former) Avon Health Authority area in South West England with an expected date of delivery between April 1991 and December 1992 were eligible to enrol. The full sample consists of 14775 live births. After birth, data were primarily collected from the study mothers and then from children via regular self-completion questionnaires and hands on assessments from the age of seven.[1] The ALSPAC cohort is largely representative of the UK population when compared with 1991 Census data; however, there is under representation of ethnic minorities, single parent families, and those living in rented accommodation. For full details of the cohort profile and study design see Boyd et al. (2013) and Fraser et al. (2013).[2]

[1] The study website contains details of all the data that is available through a fully searchable data dictionary (http://www.bristol.ac.uk/alspac/researchers/access/).

[2] Ethical approval for the study was obtained from the ALSPAC Ethics and Law Committee and the Local Research Ethics Committees.

2.2. Outcomes

We utilise two measures of mental health, the Strengths and Difficulties Questionnaire[3] (SDQ) and the Development and Well-Being Assessment[4] (DAWBA).

2.2.1. Strengths and difficulties questionnaire

The SDQ is used to assess child emotional and behavioural difficulties (Goodman et al., 2000b). Study mothers reported on the SDQ for children on four occasions; child ages 4, 7, 10, and 12 years. The SDQ is one of the most widely used questionnaires for evaluating psychological well-being amongst children and consists of 25 items that covers common areas of emotional and behavioural difficulties (emotional symptoms; conduct problems; hyperactivity/inattention; peer relationship problems; and prosocial behaviour). Responses to each question are on a three-point scale: not true, somewhat true and certainly true, coded to scores of 0, 1 and 2 respectively. Given our sample size and potential issues with using individual subscales of the SDQ (Goodman et al., 2010) we use total SDQ score defined as the count of problems on the first four scales (median: 7; inter-quartile range: 6). The Cronbach's alpha for the total SDQ scales at each measurement occasion was 0.639; 0.668; 0.670; 0.681.

2.2.2. Development and well-being assessment

The DAWBA is used to assess the presence of a range of child psychiatric disorders (Goodman et al., 2000a) and therefore provides a different measure of mental health to the SDQ. DAWBA information was collected from responses to a series of open and closed questions reported by the child's mother at three occasions; child ages 7, 10, and 13 years, which are then coded by a computer programme to predict the probability of clinical diagnoses of 15 disorders. Six probability bands were calculated and these were reversed due to software model parameterisation requirements with the lowest two categories combined due to low numbers, resulting in an ordered categorical measure giving the likelihood of diagnosis of a psychiatric disorder in decreasing order; > 70%; ~ 50%; ~ 15%; ~ 3%; ~ 0.5%.

2.3. Exposure

Our exposure variable is the experience of moving house. Study mothers were asked to report if they had moved since the previous questionnaire, providing a binary response at each occasion coded 1 if a family had moved since the last occasion and 0 if not. We also included a variable indicating the total number of moves made in the analytical period prior to the current occasion to determine whether there were any threshold effects. Given the low numbers of study families moving more than once between measurement occasions we were unable to use an absolute measure of residential move frequency.

Tables 1 and 2 show the changes in SDQ and DAWBA scores throughout the study period. Mean SDQ scores reduce with age from 8.73 at 4 years to 6.16 at 12 years. Similarly, overall distributions within the DAWBA bands reduced with age.

2.4. Covariates

A range of covariates relating to moving and mental health were used as controls in our models (Table 3). Time invariant covariates include sex and ethnicity of child, maternal and paternal age at birth, highest parental education, highest parental social class based on occupation, family structure prior to the analytical period, subjective financial difficulty, maternal anxiety, maternal depression during childhood, housing tenure, and number of residential moves made prior to the analytical period. Time variant covariates include child age in years and age squared to account for non-linear effects of age, neighbourhood deprivation as measured by quintiles of the Index of Multiple Deprivation (IMD), and a range of adverse life events as reported by the study mothers. These include separation from partner, divorce from partner, marriage, child birth, death within the family, and job loss of either the mother or her partner. Modelling separation and divorce separately allows for differentiation between married and non-married union dissolutions. Given the short time intervals between measurement occasions it was not plausible to utilise an absolute measure of frequency of events where these occurred more than once due to low numbers.

Participants included in the analytical samples were less likely to have experienced parental separation and divorce but more likely to have experienced sibling birth and parental job loss than those excluded. Children included in analyses also came from more educated, higher social class and stable families, were less likely to be non-white or live in deprived neighbourhoods, and more likely to have younger parents, have experienced more financial difficulty, and have mothers who experience depression and anxiety than those excluded (Table 3).

Table 1
Occasion level information for SDQ sample.

Occasion	Sample size	Age in years mean (SD)	Moved n (%)	Mean SDQ score (SD)
1	6033	3.94 (0.12)	1701 (28.19)	8.73 (4.52)
2	5497	6.78 (0.10)	1040 (18.92)	7.39 (4.75)
3	4399	9.63 (0.11)	1012 (23.01)	6.58 (4.76)
4	2770	11.7 (0.10)	460 (16.61)	6.16 (4.64)

SD, Standard deviation.

2.5. Statistical analysis

Because the SDQ and DAWBA were measured on different occasions we use two separate samples for analysis. 6688 children have full SDQ data providing 18,699 person-period observations while 5424 have full DAWBA data providing 11,824 person-period observations.[5] Note that there is overlap between these samples but the DAWBA sample is not a complete subsample of the SDQ sample.

Because total SDQ score represents a count of behavioural problems we fit SDQ responses using multilevel Poisson regression with an additional random effect parameter to account for over-dispersion, specified as:

$$y_{ij} \sim Poisson(\lambda_{ij})$$

$$\log(\lambda_{ij}) = \log(\exp_{ij}) + \beta_1 x_{1ij} + \beta_2 x_{2j} + u_{0j} + u_{1j} x_{1ij} + e_{ij}$$

$$\begin{bmatrix} u_{0j} \\ u_{1j} \end{bmatrix} \sim N(0, \Omega_u) \Omega_u = \begin{bmatrix} \sigma^2_{u0} & \\ \sigma_{u01} & \sigma^2_{u1} \end{bmatrix}$$

$$e_{ij} \sim N(0, \sigma^2_e)$$

where $\log(\lambda_{ij})$ denotes the count of SDQ scores for occasion i of individual j, β_1 denotes a time varying variable (in our case an occasion specific house move) x_{1ij}, β_2 denotes a time invariant variable x_{2ij}, u_{0j} denotes a person-level random intercept which allows each individual to have their own unique intercept,[6] u_{1j} denotes a person-level random slope that allows each individual to have their own unique trajectory on the moving variable, and e_{ij} is a normally distributed level 1 (occasion)

[3] For further information on the SDQ see ⟨http://www.sdqinfo.org⟩.
[4] For further information on the DAWBA see ⟨http://www.dawba.info⟩.
[5] Fig. S1 and S2 in the supplementary material outline the causes of attrition in the two analytical samples.
[6] By capturing all omitted individual-specific factors, the random intercept controls for time-invariant unobserved heterogeneity.

Table 2
Occasion level information for DAWBA sample.

Occasion	Sample size	Age in years mean (SD)	Moved n (%)	DAWBA band				
				> 70%	~ 50%	~ 15%	~ 3%	~ 0.5%
1	5255	7.46 (0.14)	1255 (23.88)	107 (2.04)	163 (3.1)	709 (13.49)	3647 (69.4)	629 (11.97)
2	4024	10.59 (0.21)	1144 (28.43)	88 (2.19)	119 (2.96)	528 (13.12)	2774 (68.94)	515 (12.8)
3	2545	13.80 (0.17)	367 (14.42)	39 (1.53)	61 (2.4)	389 (15.28)	1632 (64.13)	424 (16.66)

SD, Standard deviation.

Table 3
Sample characteristics for SDQ and DAWBA samples.

	SDQ					DAWBA				
	Analytical sample		Full sample			Analytical sample		Full sample		
	n	%	n	%	p value	n	%	n	%	p value
Separated	1189	19.71	1060	23.30	< 0.001	759	14.44	762	17.17	< 0.001
Divorced	637	10.56	458	10.08	0.423	432	8.22	365	8.23	0.987
Married	385	6.38	378	8.31	< 0.001	209	3.98	238	5.36	0.001
Sibling birth	2940	48.73	1966	42.97	< 0.001	1310	24.93	831	18.43	< 0.001
Death	99	1.64	78	1.72	0.763	58	1.10	38	0.86	0.220
Mother lost job	869	14.40	553	12.18	0.001	585	11.13	402	9.04	0.001
Father lost job	1444	23.94	912	20.08	< 0.001	896	17.05	591	13.33	< 0.001
Male	2918	48.37	4301	48.78	0.625	2572	48.94	4647	48.43	0.546
White	5853	97.02	5685	92.92	< 0.001	5086	96.78	6452	93.56	< 0.001
Education					*< 0.001*					*< 0.001*
CSE/Vocational	774	12.83	1777	27.39		543	10.33	2008	27.64	
O-level	2707	26.40	1745	26.90		2424	24.72	2039	28.06	
A-level	1531	35.27	1842	28.39		1275	36.57	2048	28.19	
Degree	645	25.49	1124	17.32		484	28.37	1171	16.12	
Social Class					*< 0.001*					*< 0.001*
I	908	15.05	632	11.41		894	17.01	646	10.23	
II	2707	44.87	2128	38.42		2424	46.13	2411	38.17	
III Non-Manual	1531	25.38	1417	25.58		1275	24.26	1673	26.48	
III Manual	645	10.69	919	16.59		484	9.21	1080	17.10	
IV/V	242	4.01	443	8.00		178	3.39	507	8.03	
Mother depressed	3164	52.44	3541	48.83	< 0.001	3017	57.41	4423	54.69	0.002
Mother anxious	1633	27.07	1572	27.07	0.997	2046	38.93	2543	36.89	0.021
Housing tenure					*< 0.001*					*< 0.001*
Owned/Mortgaged	5154	85.43	2952	68.67		4677	89.00	2621	69.80	
Private rented	550	9.12	920	21.40		357	6.79	833	22.18	
Social rented	329	5.45	427	9.93		221	4.21	301	8.02	
IMD at baseline					*< 0.001*					*< 0.001*
Q1 – Least deprived	1868	30.96	649	24.09		1792	34.10	767	27.09	
Q2	1134	18.80	427	15.85		1044	19.87	514	18.16	
Q3	1109	18.38	440	16.33		987	18.78	487	17.20	
Q4	981	16.26	503	18.67		788	15.00	499	17.63	
Q5 – Most deprived	941	15.60	675	25.06		644	12.25	564	19.92	
Family status					*< 0.001*					*< 0.001*
Steady couple	3914	64.88	4155	53.59		3524	67.06	4545	53.27	
Steady single	229	3.80	1160	14.96		190	3.62	1199	14.05	
Broken family	1510	25.03	2011	25.94		1250	23.79	2271	26.62	
New relationship	380	6.30	428	5.52		291	5.54	517	6.06	
	Mean	*SD*	*Mean*	*SD*		*Mean*	*SD*	*Mean*	*SD*	
Maternal age at birth	27.34	4.95	29.06	4.54		27.78	4.70	29.15	4.57	
Paternal age at birth	29.83	5.73	31.44	5.73		29.99	5.54	31.56	5.54	
Financial difficulties score	3.14	3.20	2.97	3.08		2.99	2.92	2.79	2.90	

SD, Standard deviation; IMD, Index of multiple deprivation; Q1, Quintile 1; CSE, Certificate of secondary education. Chi-square test statistics for difference are presented in Supplementary Tables S1 and S2.

residual. The random intercept and slope residuals are normally distributed with σ^2_{u0} the variance between intercepts, σ^2_{u1} the variance between slopes, and σ_{u01} the covariance between intercepts and slopes. Because the random slope on the house move variable allows the change in SDQ to differ for individuals in years in which they move it permits an examination of whether children exhibit greater heterogeneity in SDQ in years when they move home than in years when they are residentially stable.

DAWBA responses are fitted using multilevel ordered logistic regression, specified as:

$$\begin{aligned} \text{logit}\{\Pr(y_{ij} \leq s x_{ij})\} &\equiv \log\left\{\frac{\Pr(y_i > s)}{1-\Pr(y_i > s)}\right\} \\ &= \beta_1 x_{1ij} + \beta_2 x_{2j} + \beta_{s,3} x_{3j} + \kappa_s + u_j, \\ s &= 1.2.3.4.5 \\ u_j &\sim N(0, \sigma^2_u) \end{aligned}$$

where $y_{ij} = s$ denotes the ordinal response for occasion i of individual j, s = 1,2,3,4,5 denotes the five DAWBA bands of decreasing likelihood of psychiatric disorder diagnosis, β_1 denotes the coefficient of a time variant variable x_{1ij} (i.e. moving), β_2 denotes the coefficient of a time

invariant variable x_{2j} (i.e. sex) that is held constant across the log-odds contrasts (that is, the ordered categories of DAWBA diagnosis) where variable x_{2j} satisfies the proportional odds assumption, $\beta_{s,3}$ denotes the coefficient of a time-invariant variable x_{3j} that is allowed to vary across the log-odds contrasts where variable x_{3j} fails to satisfy the proportional odds assumption, and κ_s denotes the cut points $\kappa_1 \ldots \kappa_5$, that is the constant associated with each DAWBA band. u_j is a normally distributed person-level random effect.

We extend each of these models to utilise a within-between random effect multilevel modelling approach (Bell and Jones, 2015), a method gaining popularity in the analysis of residential and neighbourhood transitions (Morris et al., 2016a; Nieuwenhuis et al., 2016). In longitudinal model formulations such as those above the coefficient of interest β_1 represents the *combined* effect of two separate components or 'effects' of the variable x_1. The within-between random effect model allows these components to be estimated separately.[7] In our case the first component compares the outcomes of one person who experienced a move to a *different* person who experienced no move. This is termed the 'between person' component as it estimates the difference in outcomes between different people. The second component compares the outcomes of a person who experienced a move at one time to themselves at a different time at which they experienced no move. This is termed the 'within person' component as it estimates the difference in outcomes within the same person at different time points. The difference between the between and within components is important. The between person component compares the outcomes of movers and stayers, who are likely to differ across a range of individual-specific factors (confounders), and so it can only be used to infer associational differences. The within-person component compares the outcomes of the same person at different occasions[8] and so by using each person as their own control unit provides a less biased measure of how a change in exposure relates to a change in outcome.[9] The within component therefore provides greater freedom to infer causal interpretations to associations (i.e. that moving causes subsequent changes in mental health).

All models are fitted in the MLwiN software[10] using Markov Chain Monte Carlo (MCMC) methods (Browne, 2015)[11] as implemented in the MLwiN software and called from within Stata v14 (StataCorp, College Station, TX, USA) using the runmlwin function (Leckie and Charlton, 2013). All results are presented as mean draws from parameter estimates with 95% Credible Intervals. We present results from three models: (1) results adjusted for covariates but with life events excluded to assess the impact of moving on mental health; (2) decomposition of the association between moving and mental health into its constituent between and within parts to test if movers have poorer mental health because they moved or because they fundamentally differ to stayers; (3) inclusion of life events to test for bias due to unobserved confounding caused by the exclusion of time varying life events.

3. Results – do movers and stayers differ?

3.1. SDQ

Results from the SDQ analysis are presented in Table 4. In the covariate adjusted model (Model 1) there is strong evidence that moving is associated with higher SDQ scores, but no evidence for a cumulative effect of moves. A random slope is included in model 1 on the move coefficient, and the negative intercept slope covariance provides evidence that there is heterogeneity in SDQ between movers and stayers; residentially stable children have more variable mental health than movers. Neighbourhood deprivation was unrelated to child SDQ scores while the coefficient for sex shows that boys had higher SDQ scores than girls, as did children with older mothers and those who had experienced greater financial difficulty. Children with highly educated parents had lower scores than those whose parents had lower levels of education scores, and a similar trend was found for parental occupational social class. Maternal self-reported depression and anxiety were strongly associated with increased child SDQ scores, although it is possible that a study mother's responses on child mental health may in part reflect her own mental health. Children who had experienced parental separation *prior* to the analytical period had higher SDQ scores than those from stable two parent families, but interestingly there was no clear difference between children from stable single parent families and those from stable two parent families. There was no evidence for associations between SDQ and child age, ethnicity, housing tenure or paternal age at birth.

Model 2 decomposes the association between moving and SDQ scores into between and within parts to determine the extent to which the association observed in Model 1 is being driven by differences between individuals and/or differences within individuals caused by moving. The large between component suggests that the difference in SDQ scores between mobile and non-mobile children is being heavily driven by unobserved between-child differences. That is, the higher SDQ scores of mobile children are due in part to unmeasured factors; mobile children have poorer mental health regardless of the fact that they have moved. Turning to the within component of Model 2, there is a positive association between moving and SDQ score, suggesting that for a given child moving leads to an increase in subsequent SDQ score. The coefficient is smaller than that for the between component, implying that unobserved between-child factors provide a greater contribution to the higher SDQ scores of mobile children than the experience of making a residential move. However, the fact that there is a positive within-child component indicates that moving may lead to poorer child mental health. The random slope is now included for the within-individual move coefficient; the negative intercept slope covariance suggests that children are more similar in terms of SDQ in periods in which they move than in periods in which they are stable. That is, there is greater heterogeneity amongst non-movers than movers. Because the slope is based upon the within-child effect of moving which is itself associated with higher SDQ, the results suggest that children with lower SDQ scores in stable periods experience disproportionately worse mental ill health because of moving than children with higher SDQ scores. That is, moving is more damaging for healthier children with fewer behavioural difficulties than those whom already have greater behavioural difficulties. Failing to include a random slope on the within-individual move variable would force the incorrect assumption that the effect of moving on SDQ is uniform and that all children respond to moving in the same way.

Comparison of movers and stayers (Supplementary Table S3) shows that in the SDQ sample children who experience major life events are more likely to move than children who experience no event. Clearly, excluding life events from Model 2 may have led to a biased within-child component due to time varying confounding by life events. Model 3 includes life event data to assess this confounding. Remarkably, the inclusion of major life events did not attenuate the

[7] We decompose the coefficient β_1 by entering separate components for the between and within effects as follows: $\beta_1^W(x_{ij}-\bar{x}_j)+\beta_2^B\bar{x}_j$ where The between coefficient β_1^B is the individual level average of a given life event $\bar{x}_j$. (the proportion of occasions in which an event occurred for individual j) and the within component β_2^W is the deviation from this average $x_{ij}-\bar{x}_j$. at a given occasion i.

[8] The within component is estimated from a smaller subsample of individuals who move on at least one occasion and are residentially stable on at least one occasion.

[9] While the within component accounts for all time-invariant observed and unobserved person level factors, it is still subject to time-varying confounding.

[10] See http://www.bristol.ac.uk/cmm/software/mlwin/ for details.

[11] We specified a burn-in of 500 iterations and a monitoring chain of 25000 iterations using orthogonal parameterisation to ensure suitable chain mixing and sufficiently large estimated sample sizes.

Table 4
Regression results from SDQ sample.

	Model 1: Covariate adjusted		Model 2: Between within		Model 3: Between within with events	
	Coefficient	95% CI	Coefficient	95% CI	Coefficient	95% CI
Residential move	0.039	0.020 to 0.058				
RM between component			0.060	0.010 to 0.109	0.054	0.008 to 0.103
RM within component			0.031	0.009 to 0.054	0.030	0.007 to 0.052
IMD between component			0.011	−0.008 to 0.031	0.011	−0.010 to 0.031
IMD within component			0.001	−0.013 to 0.014	0.001	−0.013 to 0.014
Cumulative moves	0.014	−0.005 to 0.034	0.008	−0.014 to 0.029	0.010	−0.011 to 0.032
Separation					0.024	−0.007 to 0.056
Divorce					0.024	−0.019 to 0.066
Marriage					0.013	−0.036 to 0.062
Sibling birth					0.049	0.030 to 0.069
Family death					−0.001	−0.093 to 0.089
Maternal job loss					0.029	−0.003 to 0.060
Paternal job loss					0.003	−0.022 to 0.027
Male	0.130	0.105 to 0.155	0.131	0.106 to 0.156	0.131	0.104 to 0.155
Early childhood moves	0.017	−0.004 to 0.039	0.015	−0.006 to 0.036	0.015	−0.006 to 0.035
Non-white	0.007	−0.069 to 0.083	0.008	−0.065 to 0.081	0.009	−0.065 to 0.082
Age in years	−0.102	−0.116 to −0.087	−0.101	−0.115 to −0.086	−0.095	−0.110 to −0.080
Age in years squared	0.004	0.003 to 0.005	0.004	0.003 to 0.005	0.004	0.003 to 0.005
Private rented	0.036	−0.015 to 0.088	0.030	−0.021 to 0.082	0.034	−0.019 to 0.084
Social rented	−0.046	−0.100 to 0.009	−0.055	−0.114 to 0.003	−0.054	−0.110 to 0.002
O-level	−0.079	−0.123 to −0.035	−0.079	−0.122 to −0.035	−0.080	−0.126 to −0.036
A-level	−0.109	−0.153 to −0.067	−0.110	−0.154 to −0.066	−0.110	−0.154 to −0.063
Degree	−0.103	−0.156 to −0.049	−0.104	−0.156 to −0.054	−0.107	−0.159 to −0.053
II	0.046	0.006 to 0.087	0.047	0.003 to 0.089	0.047	0.005 to 0.088
III Non-Manual	0.070	0.021 to 0.119	0.071	0.023 to 0.121	0.072	0.024 to 0.121
III Manual	0.077	0.018 to 0.136	0.080	0.020 to 0.139	0.081	0.024 to 0.139
IV/V	0.135	0.056 to 0.215	0.133	0.055 to 0.212	0.138	0.060 to 0.216
Maternal age in years	−0.007	−0.011 to −0.003	−0.007	−0.011 to −0.003	−0.006	−0.01 to −0.002
Paternal age in years	0.000	−0.003 to 0.004	0.001	−0.003 to 0.004	0.001	−0.002 to 0.004
Maternal depression	0.167	0.138 to 0.196	0.168	0.140 to 0.196	0.169	0.141 to 0.197
Maternal anxiety	0.093	0.063 to 0.125	0.094	0.064 to 0.124	0.094	0.064 to 0.123
Financial difficulty	0.022	0.018 to 0.027	0.022	0.017 to 0.027	0.022	0.017 to 0.027
Single parent	0.041	−0.029 to 0.111	0.039	−0.028 to 0.108	0.036	−0.031 to 0.105
Separated	0.042	0.010 to 0.073	0.039	0.008 to 0.071	0.030	−0.004 to 0.063
New relationship	0.030	−0.022 to 0.082	0.030	−0.025 to 0.084	0.026	−0.027 to 0.08
IMD - Q2	−0.013	−0.052 to 0.026	−0.022	−0.066 to 0.020	−0.022	−0.064 to 0.019
Q3	0.002	−0.037 to 0.042	−0.018	−0.070 to 0.036	−0.018	−0.069 to 0.032
Q4	−0.005	−0.046 to 0.036	−0.033	−0.099 to 0.030	−0.033	−0.096 to 0.032
Q5 - Most deprived	−0.014	−0.059 to 0.029	−0.052	−0.129 to 0.023	−0.053	−0.132 to 0.028
Constant	2.331	2.176 to 2.481	2.310	2.156 to 2.461	2.233	2.076 to 2.392
Level 2 intercept variance	0.224	0.213 to 0.235	0.215	0.205 to 0.225	0.214	0.204 to 0.224
Level 2 slope variance	−0.023	−0.033 to −0.014	−0.019	−0.029 to −0.009	−0.018	−0.028 to −0.009
Intercept slope covariance	0.010	0.004 to 0.023	0.014	0.007 to 0.022	0.014	0.006 to 0.027
Pseudo level 1 variance	0.021	0.017 to 0.024	0.020	0.016 to 0.024	0.020	0.016 to 0.024
DIC	94271.98		94269.45		94282.42	

95% CI, 95% Credible interval; RM, Residential move; IMD, Index of multiple deprivation; Q1, Quintile 1; DIC, Bayesian deviance information criterion.

within-child effect of moving on SDQ scores, providing evidence that the within-child moving association in Model 2 was not being driven (confounded) by the occurrence of life events. The fact that there is a positive within-child component even after consideration of major life events permits greater freedom for drawing causal inferences from the data and suggests that moving may have a subsequent negative effect on child mental health. The negative intercept slope covariance remains, indicating that the longitudinal association between moving and mental health depends in part on mental health 'pre-move'. Considering the effects of major life events, the only robust association is reported between sibling birth and increased SDQ scores.

3.2. DAWBA

Table 5 displays the results from the DAWBA analysis where the coefficients represent the log-odds of being in DAWBA band *s* or lower (i.e. of having *better* mental health). The "/cut constant" coefficients represent the log-odds of being in each decreasing DAWBA band when all else is zero, for example "/cut1 constant" refers to the log-odds of being in the second DAWBA band or lower compared to the highest band. Proportional odds assumptions were satisfied for all variables except for sex and financial difficulties, the effects of which were allowed to vary in strength across the across the log-odds contrasts (the DAWBA bands). The "/cut male" and "/cut financial difficulty" coefficients therefore represent the (non-proportional) log-odds of being male and increased financial difficulty respectively across each of the DAWBA categories. For example, the coefficient "/cut1 male" refers to the log-odds of being in the second DAWBA band or lower compared to the highest band for males compared to females. Like the SDQ results there is an association between moving and poorer mental health defined by DAWBA diagnosis, and given that this association satisfied the proportional odds assumption indicates that moving and diagnosis was consistent across the log-odds contrasts. Again, no associations were observed between mental health and either cumulative moves or current neighbourhood deprivation. Age was associated with better mental health but there was a negative quadratic effect. Maternal depression and maternal anxiety were both strongly associated with poorer mental health, while children from separated families were more likely to be in higher DAWBA bands than those from stable two parent families. There was evidence that children with

Table 5
Regression results from DAWBA sample.

	Model 1: Covariate adjusted		Model 2: Between within		Model 3: Between within with events	
	Coefficient	95% CI	Coefficient	95% CI	Coefficient	95% CI
Residential move	−0.186	−0.364 to −0.013				
RM between component			−0.372	−0.695 to −0.055	−0.340	−0.675 to −0.023
RM within component			−0.149	−0.329 to 0.030	−0.129	−0.313 to 0.051
IMD between component			0.201	0.011 to 0.395	0.202	0.010 to 0.406
IMD within component			0.047	−0.092 to 0.183	0.048	−0.085 to 0.177
Cumulative moves	0.120	−0.008 to 0.254	0.188	0.023 to 0.352	0.177	0.015 to 0.339
Separation					−0.189	−0.447 to 0.063
Divorce					0.106	−0.206 to 0.434
Marriage					−0.358	−0.756 to 0.045
Sibling birth					−0.227	−0.398 to −0.063
Family death					−0.510	−1.335 to 0.279
Maternal job loss					−0.326	−0.562 to −0.099
Paternal job loss					0.129	−0.066 to 0.308
Early childhood moves	−0.049	−0.105 to 0.004	−0.050	−0.110 to 0.007	−0.047	−0.104 to 0.012
Non-white	0.053	−0.337 to 0.459	0.068	−0.342 to 0.469	0.073	−0.301 to 0.436
Age in years	−0.070	−0.263 to 0.132	−0.090	−0.285 to 0.109	−0.132	−0.336 to 0.064
Age in years squared	0.004	−0.006 to 0.013	0.005	−0.004 to 0.014	0.006	−0.003 to 0.016
Private rented	0.061	−0.179 to 0.311	0.062	−0.210 to 0.330	0.064	−0.192 to 0.332
Social rented	0.054	−0.190 to 0.303	0.063	−0.201 to 0.334	0.063	−0.197 to 0.326
O-level	−0.305	−0.581 to −0.033	−0.289	−0.582 to 0.005	−0.287	−0.576 to 0.024
A-level	−0.302	−0.511 to −0.090	−0.301	−0.515 to −0.091	−0.301	−0.513 to −0.088
Degree	−0.213	−0.462 to 0.035	−0.213	−0.458 to 0.035	−0.211	−0.448 to 0.048
II	−0.260	−0.579 to 0.065	−0.276	−0.603 to 0.044	−0.274	−0.596 to 0.063
III Non-Manual	−0.129	−0.564 to 0.329	−0.103	−0.574 to 0.333	−0.131	−0.600 to 0.349
III Manual	0.005	−0.016 to 0.026	0.004	−0.016 to 0.025	0	−0.021 to 0.022
IV/V	0.009	−0.007 to 0.025	0.009	−0.007 to 0.024	0.009	−0.008 to 0.025
Maternal age in years	−0.267	−0.586 to 0.054	−0.291	−0.599 to 0.031	−0.290	−0.610 to 0.026
Paternal age in years	0.226	−0.115 to 0.580	0.243	−0.107 to 0.608	0.252	−0.112 to 0.602
Maternal depression	−0.422	−0.568 to −0.274	−0.418	−0.567 to −0.268	−0.415	−0.559 to −0.266
Maternal anxiety	−0.429	−0.579 to −0.286	−0.429	−0.577 to −0.281	−0.430	−0.577 to −0.282
IMD - Q2	−0.114	−0.301 to 0.079	−0.294	−0.547 to −0.036	−0.298	−0.561 to −0.035
Q3	−0.089	−0.291 to 0.106	−0.445	−0.849 to −0.044	−0.469	−0.886 to −0.057
Q4	−0.262	−0.482 to −0.049	−0.814	−1.398 to −0.249	−0.825	−1.421 to −0.239
Q5 - Most deprived	0.018	−0.230 to 0.260	−0.715	−1.475 to 0.022	−0.739	−1.535 to 0.015
Single parent	0.026	−0.334 to 0.398	0.028	−0.352 to 0.386	0.030	−0.338 to 0.395
Separated	−0.412	−0.579 to −0.237	−0.417	−0.597 to −0.248	−0.357	−0.534 to −0.171
New relationship	−0.020	−0.301 to 0.269	−0.023	−0.318 to 0.270	0	−0.296 to 0.304
/cut1 constant	−2.032	−3.312 to −0.825	−2.103	−3.377 to −0.830	−1.722	−2.994 to −0.442
/cut1 Male	−0.145	−0.318 to 0.028	−0.148	−0.325 to 0.030	−0.158	−0.329 to 0.018
/cut1 Financial difficulty	−0.060	−0.100 to −0.022	−0.059	−0.095 to −0.024	−0.061	−0.098 to −0.023
/cut2 constant	3.641	2.367 to 4.875	3.586	2.309 to 4.868	3.959	2.677 to 5.248
/cut2 Male	−0.670	−0.830 to −0.503	−0.686	−0.855 to −0.516	−0.687	−0.851 to −0.519
/cut2 Financial difficulty	−0.123	−0.155 to −0.091	−0.123	−0.156 to −0.093	−0.122	−0.152 to −0.093
/cut3 constant	5.836	4.544 to 7.089	5.791	4.498 to 7.074	6.156	4.870 to 7.465
/cut3 Male	−0.699	−0.937 to −0.455	−0.726	−0.972 to −0.484	−0.720	−0.977 to −0.473
/cut3 Financial difficulty	−0.127	−0.166 to −0.086	−0.127	−0.172 to −0.084	−0.125	−0.166 to −0.085
/cut4 constant	7.006	5.694 to 8.293	6.962	5.641 to 8.254	7.325	5.991 to 8.653
/cut4 Male	−0.530	−0.888 to −0.189	−0.562	−0.912 to −0.228	−0.554	−0.888 to −0.209
/cut4 Financial difficulty	−0.138	−0.189 to −0.085	−0.137	−0.191 to −0.083	−0.134	−0.186 to −0.083
VPC	0.520		0.521		0.519	
DIC	19802.28		19788.21		19803.48	

RM, Residential move; IMD, Index of multiple deprivation; Q1, Quintile 1; VPC, Variance partition coefficient; DIC, Bayesian deviance information criterion.

lower social class parents had poorer mental health, although those with degree educated parents had poorer levels of mental health. No associations were observed between DAWBA categorisation and ethnicity, maternal age, paternal age or housing tenure. Boys were less likely to be classified in a lower DAWBA band than girls, as were children who had experienced a greater number of financial difficulties in early childhood. These associations showed a non-proportional trend by which coefficients were larger in each successive band.

The results from Model 2 show that most the association between moving and poorer mental health is again due to unobserved between-child differences. The between-child component shows that there is strong evidence that mobile children have poorer underlying levels of mental health than non-mobile children. The point estimate for the within-individual moving coefficient is negative but Credible Intervals are wide, providing only suggestive evidence that moving may lead to subsequently poorer mental health as measured by DAWBA. There was a positive coefficient for the between-child IMD component suggesting that all else considered, children living in more deprived neighbourhoods tended to have better mental health as measured by DAWBA.

As with the SDQ sample, children who experienced major life events were generally more likely to move than children who do not experience them (Supplementary Table S3). Accounting for these time varying events in Model 3 shows that the between-individual component remains robust, suggesting that movers as a group are more likely to have poorer DAWBA diagnoses than stayers for reasons beyond moving and other life events. The inclusion of life events attenuates the within-child moving association and reduces statistical support, suggesting that the weak within-child association observed in Model 2 may be confounded by major life events. Regarding life events themselves, robust associations with mental health are observed only for sibling

birth and maternal job loss, both of which are associated with poorer mental health. The coefficient for family death is larger than for any other life event but Credible Intervals are wide, reflecting the small number of cases.

3.3. Is the effect of moving uniform?

One assumption of our analyses thus far is that movers and stayers are homogenous groups with one to one associations with mental health, that is, staying is a positive experience and moving is a negative experience for all children. Previously, the literature has treated this assumption as intuitive, however there is evidence that the effects of moving can vary depending on whether a move (or lack of move) is desired or undesired (Woodhead et al., 2015). We were unable to formally test for effect moderation of moving or staying by preference due to a lack of available data on family moving preferences. However, to examine whether the effects of moving are homogenous we created a quasi-move preference variable based upon neighbourhood deprivation transitions whereby moves were classified as preferred if they were to less deprived neighbourhoods, neutral if they were to similarly deprived neighbourhoods, and unwanted if they were to more deprived neighbourhoods. The results of analyses on the SDQ and DAWBA measures using the quasi-preference variable are displayed in Table 6 (full model results in Supplementary Table S4 and S6). The results suggest that the effect of moving on subsequent mental health is non-uniform. On both the SDQ and DAWBA measures, there was only suggestive evidence that children who made 'preferred' moves experienced poorer subsequent mental health than children who did not move, with Credible Intervals covering zero. However, on both measures children who made 'neutral' moves had poorer subsequent mental health compared to children who did not move, although the statistical support for this association on the DAWBA measure was reduced when life events were accounted for. The point estimate in the SDQ sample for 'unwanted' moves was higher than for the other preference groups suggesting that unwanted moves may have the greatest impact upon subsequent mental health compared to other types of moves, but the wide credible intervals suggest that this could be statistical noise due to low numbers (Supplementary Table S5). DAWBA numbers for this group were lower still (Supplementary Table S7) resulting in a noisy estimate with wide credible intervals. These results suggest that moving is not a uniform experience for children, but may depend in part on the nature of moves. If we make the assumption that moves to less deprived neighbourhoods are preferred moves (a fair assumption given the significant economic cost that is associated with moving to more affluent areas) and that those to more deprived areas are unwanted moves (a reasonable assumption based upon the desire of people to make moves up the neighbourhood ladder (Bolt et al., 2009)), then our quasi-move preference variable can be considered to capture some underlying preference towards moving. It is however unlikely that these results point to neighbourhoods or 'place' as an effect modifier given the lack of deprivation effects observed in the main analyses over and above the effect of moving, but they do highlight the presence of heterogeneity within movers and imply that a simple dichotomy of movers vs stayers is overly simplistic.

Table 6
Main effects regression results from quasi-move preference models.

	Model 1: Covariate adjusted		Model 2: Life event adjusted	
	Coef.	95% CI	Coef.	95% CI
SDQ				
No move	Ref. Cat			
Quasi-preferred move	0.015	−0.009 to 0.040	0.014	−0.011 to 0.040
Quasi-neutral move	0.034	0.008 to 0.059	0.032	0.007 to 0.058
Quasi-unwanted move	0.037	−0.007 to 0.078	0.036	−0.008 to 0.080
DAWBA				
No move	Ref. Cat			
Quasi-preferred move	−0.188	−0.376 to 0.006	−0.161	−0.354 to 0.041
Quasi-neutral move	−0.247	−0.465 to −0.016	−0.232	−0.461 to 0.005
Quasi-unwanted move	0.091	−0.351 to 0.546	0.133	−0.314 to 0.586

Ref. Cat, Reference category.

4. Discussion

Our results shed new light on the relationship between moving and mental health and make several contributions to the literature. First, decomposing the association between moving and poor mental health allows us to demonstrate for the first time the relative similarities and differences of movers and stayers. Our results show that most the association between moving and mental ill health is driven by unobserved between-individual factors; that is, that movers and stayers are fundamentally different types of people with regards to mental health. These unobserved between-individual factors account for most of the difference in mental health between mobile and non-mobile children. The implication is that mobile children as a group have a greater underlying propensity towards poor mental health than non-mobile children. These unobserved between-individual differences remained even in the presence of a wider range of variables than has been considered in many previous studies. Given that we control for many family level socio-economic and demographic characteristics, it is possible that these unobserved differences may relate to factors such as child personality, genetics or family level wellbeing. Second, the decomposition provides to our knowledge the first evidence of within-individual associations between moving and mental health amongst children. Our findings suggest that children experience poorer mental health in periods following a residential move than in periods in which they are residentially stable. The within individual associations had greater statistical support for SDQ than DAWBA, which may reflect a genuine phenomenon by which moving has a larger negative impact on behavioural problems measured by the SDQ than psychiatric diagnoses measured by the DAWBA, or a statistical issue caused by data constraints imposed by fewer occasions and observations in the DAWBA sample. Given the positive association between age and better mental health in the DAWBA analyses it is also possible that the weaker within-individual association may be due to the older sample of children than in the SDQ sample. Third, our analysis suggests that the association between moving and mental health as measured by SDQ is robust to confounding by major life events. This may be more important for some measures of mental health than others given the small attenuating effect of within individual associations that life events had in the DAWBA but not the SDQ analyses, suggesting that the DAWBA results from models unadjusted for life events may have been slightly biased. This would fit with inconsistent findings between previous studies assessing the importance of life events in the relationship between moving and poor mental health (Dong et al., 2005; Tunstall et al., 2015); future studies should take account of life events to assess potential confounding or be aware of potential biases where data limitations prevent this. Fourth, we demonstrate that the mover/stayer dichotomy is false. The presence of a negative intercept slope covariance on the moving variable in the SDQ analyses suggest that the effects of moving on mental health vary between children; children who have better mental health prior to moving experience a greater decline in mental health following the move than those who have poorer mental health prior to moving. Our results using quasi-move preference provide further support for heterogeneity of mental health effects

amongst movers.

Interestingly we did not observe any within-individual associations between neighbourhood deprivation and mental health, consistent with other studies that have utilised similar designs (Jokela, 2015, 2014) or examined the effect of deprivation over and above the impact of making a residential move (Gambaro and Joshi, 2016). This suggests that it may be the move itself rather than changes to neighbourhood context that matter for child mental health when moving through neighbourhoods. This finding is in contrast to some studies which have suggested moving to more deprived neighbourhoods is associated with poorer mental health (Leventhal and Brooks-Gunn, 2003; Ludwig et al., 2012). There are various possibilities for these disparate findings; it may be that the associations observed in these studies have been driven more by the act of moving than the specific deprivation trajectories; they may have suffered from unobserved confounding that we were able to avoid by using rich cohort data and an appropriate analytical approach; or it could be due to systematic differences in the samples. Regardless of the precise mechanism that is driving these differences, our findings highlight the importance for future studies to determine the extent to which any observed associations between deprivation transitions and health capture the effects of moving rather than effects of changing neighbourhoods. The results of our quasi-preference analysis suggest that moving may not be a uniform experience for all children, conforming to findings from other UK studies (Tunstall et al., 2014, 2012). However, statistical support for differences between our quasi-preference groups was weak and future studies with larger sample sizes may be able to explore this area further.

The major limitation of this work relates to the accuracy of the SDQ and DAWBA measures, which do not provide perfect measures of child psychiatric illness compared to clinician diagnoses. However, such diagnoses are unavailable to our study, and there is a large body of work validating the SDQ and DAWBA measures as diagnostic tools in population data (Goodman et al., 2000a, 2000b). Another limitation is that we were unable to decompose movers and stayers into groups defined by moving/staying preference. However, this assumption is more likely to be satisfied in studies such as ours that involve children instead of adults because young children are not involved in the moving decision making process and do not have the vested beneficial interests that adults do when considering a residential move. Our analyses separating moves into positive and negative experiences based upon neighbourhood deprivation transitions suggest that failure to decompose movers may ignore heterogeneity within this group, although this analysis did not directly assess moving preference. A further limitation is the possibility that the within-child associations were driven by school changes (Winsper et al., 2016); residential moves may be accompanied by non-compulsory school changes which could further increase the environmental change that children must adapt to and the erosion of child social networks.

In conclusion, our findings suggest that moving in childhood is associated with subsequent behavioural difficulties. Decomposing this association into its constituent between and within individual components shows that while most of the association is due to unobserved differences between 'movers' and 'stayers', there is evidence that moving house may have an independent, albeit smaller detrimental impact upon subsequent child mental health. This finding holds for behavioural but not psychiatric measures of mental health, suggesting that the relationship between moving and poor mental health may be dependent on the measure of mental health under examination.

Acknowledgements

We are extremely grateful to all the families who took part in this study, the midwives for their help in recruiting them, and the whole ALSPAC team, which includes interviewers, computer and laboratory technicians, clerical workers, research scientists, volunteers, managers, receptionists and nurses. We are also grateful to the Editor and Reviewers for helpful comments on an earlier version of this manuscript. Ethical approval for the study was obtained from the ALSPAC Ethics and Law Committee and the Local Research Ethics Committees. The UK Medical Research Council and the Wellcome Trust (Grant ref: 102215/2/13/2) and the University of Bristol provide core support for ALSPAC. TM is funded by an ESRC PhD studentship in Advanced Quantitative Methods (ES/J50015X/1). KN is funded by the National Institute for Health Research Collaboration for Leadership in Applied Health Research and Care (NIHR CLAHRC) West at University Hospitals Bristol NHS Foundation Trust. The views expressed are those of the author(s) and not necessarily those of the NHS, the NIHR or the Department of Health.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.healthplace.2017.06.004.

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